Patent
TS7613 (US)
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Date: November 25, 2003

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of IAN G. ARCHIBALD, STEPHEN J. GILLESPIE, STEVEN A. RICHARDSON, and WILLIAM J. S. HIRST	
Serial No. 10/623,248	Group Art Unit: 2856
Filed July 18, 2003	
LOCATING A SOURCE OF EMANATIONS	November 25, 2003

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CLAIM TO PRIORITY

Applicants reaffirm the claim for the benefit of filing date of the following foreign patent application referred to in Applicants' Declaration:

European application Serial No. 02255174.1 filed July 24, 2002

A copy of the application certified by the European Patent Office is enclosed.

Respectfully submitted,

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Attachment

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Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. Patent application No. Demande de brevet n°

02255174.1

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

Anmeldung Nr:
Application no.: 02255174.1
Demande no:

Anmeldetag:
Date of filing: 24.07.02
Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Locating a source of emanations

In Anspruch genommene Prioriät(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

G01V9/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR

TS 7613 EPC

Hsb

LOCATING A SOURCE OF EMANATIONS

The present invention relates to a method of determining the position and emission rate of at least one source of emanations into an intervening medium.

The article Wilkinson et al, 'Process site emission quantification and location from optical remote sensing measurements' Proc. SPIE-Int. Soc. Opt. Eng; 1996, Vol. 2883, pages 355-364 discloses such a method.

The known method comprises the steps of:

(a) selecting a set of measurement locations;

(b) measuring the concentrations of the emanations in the intervening medium at the measurement locations to obtain a set of observed data;

(c) measuring the velocity of the intervening medium at a location;

(d) postulating a dispersion model that allows the calculation for a position of the concentration of the emanation arising there from a source;

(e) postulating a set of source models consisting of source parameters, such as the position(s) of assumed source(s) and assumed emission rate(s);

(f) calculating with the dispersion model for each postulated source model the concentration that would arise at the measurement location(s) to obtain a set of synthetic data for each postulated source model;

(g) comparing the set(s) of synthetic data with the observed data to select the source model that gives the closest fit; and

(h) outputting the position and emission rate of the at least one source assumed in the source model that gives the closest fit.

The measurements carried out to obtain the set of observed data were done using open-path measurements. In the open-path measurements, the concentration of emanations is measured over a path having a length of up to 500 meters by means of a sensor to yield a path-integrated gas concentration measurement.

This method was applied on a refinery to locate gaseous leaks and their associated mass release rates (emission rates). The relatively low concentrations typically resulting in the atmosphere from such leaks require long measurement paths for the influence of the sought gas or gases to be measurable. However, because the concentration is detected along the full length of a line, the likelihood that emanations from a source would be detected is relatively high.

A disadvantage of the known method is that it is laborious to set up the devices needed to carry out the open-path measurements.

It is an object of the present invention to overcome this disadvantage. To this end the method of determining the position and emission rate of at least one source of emanations into an intervening medium according to the present invention comprises the steps of:

(a) selecting a set of measurement locations;

(b) measuring the concentration of the emanations in the intervening medium at the measurement locations to obtain a set of observed data;

(c) measuring the velocity of the intervening medium at a location;

(d) postulating a dispersion model that allows the calculation for a position of the concentration of the emanation arising there from a source;

(e) postulating a set of source models consisting of source parameters, such as the position(s) of assumed source(s) and assumed emission rate(s);

(f) calculating with the dispersion model for each postulated source model the concentration that would arise at the measurement location(s) to obtain a set of synthetic data for each postulated source model;

(g) comparing the set(s) of synthetic data with the observed data to obtain the source model that gives the closest fit; and

(h) outputting the position and emission rate of the at least one source assumed in the source model that gives the closest fit,

wherein the concentrations of the emanations are measured by means of point measurements using an ultra-sensitive detector with an appropriate response time.

The method of the present invention can suitably be used for determining the position and emission rate of leaks on a refinery, chemical plant or similarly large and complicated areas of processing activities and their related emissions.

An area of application that currently attracts attention is hydrocarbon prospecting, or locating underground hydrocarbon reservoirs. Already in the nineteen sixties it was proposed to use measurements of concentrations of hydrocarbon gases escaping through the overburden to determine the position of an underground hydrocarbon reservoir. Examples are given in British patent specification No. 997 877 and USA patent specification No. 3 734 489. Basically the methods disclosed in these publications relied on physically traversing a line along which the concentration increased until eventually arriving at the source of the emanation, as indicated by the concentration measurements being greatest at that location. These methods entail considerable effort and for many regions of interest they are impractical to execute.

The present invention further provides a method of remotely determining the position of a hydrocarbon reservoir located in an earth formation, which method comprises:

(a) selecting a set of measurement locations;

(b) measuring the concentration of a selected component in the atmosphere at the measurement locations to obtain a set of observed data;

(c) measuring the wind velocity at a location;

(d) postulating a dispersion model that allows the calculation for a position of the concentration of the selected component arising there from a source;

(e) postulating a set of source models consisting of source parameters, such as the position(s) of assumed source(s) and assumed emission rate(s);

(f) calculating with the dispersion model for each postulated source model the concentration that would arise at the measurement location(s) to obtain a set of synthetic data for each postulated source model;

(g) comparing the set(s) of synthetic data with the observed data to obtain the source model that gives the closest fit; and

(h) outputting the position and emission rate of the at least one source assumed in the source model that gives the closest fit to obtain a representation of the position of the hydrocarbon reservoir,

wherein the concentrations of the emanations are measured by means of point measurements using an ultra-sensitive detector with an appropriate response time.

Applicant had now found that point measurements using an ultra-sensitive detector with an appropriate response time can be successfully used to replace the open-path measurements.

An advantage of the method according to the present invention is that it allows measuring at a relatively

large distance away from the source (order of magnitude of kilometres). This constitutes the range from which the source location may be remotely determined without the need for a closer approach. And, because the detector has an appropriate response time, rapidly varying fluctuations in the concentration can be detected as well. A further advantage is that because a single instrument is used, it can easily be relocated to a position that is judged to be more advantageous in the light of the measurements and analysis previously obtained.

An ultra-sensitive detector is a detector that has a sensitivity sufficient to register the emanations from a source, at a predetermined distance from the source in the direction of flow of the intervening medium. If the intervening medium is the atmosphere, in the direction of flow would be downwind.

The appropriate response time is suitably comparable to or less than the fluctuation-time of the concentration. Suitably, the response time is less than 10 seconds and more suitably less than 1 second. The response time is the time it takes the detector to reach a pre-determined fraction, for example 90%, of a step change in the measured quantity.

A suitable detector for this specific application is described in the article 'A field-portable, laser-diode spectrometer for the ultra-sensitive detection of hydrocarbon gases', by Gibson et al, Journal of Modern Optics, 2002, vol. 49, No. 5/6, pages 769-776. The known detector has a lower detection level of less than 100 parts per trillion, or better for the particular emanating component.

In order to obtain sufficient information per measurement point, the measurement time is suitably comparable to the time it takes to for the emanation from

the source to reach the measurement point. In case there are more sources, the measurement time is suitably comparable to the time it takes for the emanation from the farthest source to reach the measurement point.

In the method of the invention a dispersion model is used. An example of the dispersion model is the Gaussian plume model as described in the Wilkinson article.

The dispersion model yields the point concentration of the emanation at a measurement point as a function of the yet unknown source location(s), emission rate(s), and velocity of the intervening medium. The velocity is a vector quantity having a magnitude (speed) and a direction. In addition, the intensity of turbulence in the intervening medium is determined, and is included in the dispersion model as well.

In order to find the location(s) and the emanation rate(s) from the source(s), a process of inversion must be carried out.

According to the Wilkinson article there are many inversion processes, and in the article one of these is described in more detail.

The inversion techniques have three steps in common. The first step is postulating a set of source models consisting of source parameters, such as the position(s) of assumed source(s) and assumed emission rate(s).

The second step is calculating with the dispersion model for each postulated source model the concentration that would arise at the measurement location(s) to obtain a set of synthetic data for each postulated source model.

The third step is comparing the set(s) of synthetic data with the observed data to obtain the source model that gives the closest fit.

One method of comparing the synthetic data with the observed data is based on Bayesian statistical inference, see the Wilkinson article. Another is based on a

generalized linear least squares inversion method. In this method a set of parameters of a source model is estimated such that the difference between the observed data and the synthetic data is minimized based on a specific norm. The synthetic data are calculated with the dispersion model.

The last step of the methods of the invention is outputting the result of the comparison, in the form of the position and the emission rate of the at least one source assumed in the source model that gives the closest fit. The output can be in the form of a contour map, or in a table with coordinates of the source or sources with the emission rates.

The invention is not only applicable to a gaseous component emanating into a gaseous intervening medium, the invention can as well be applied to a solid, liquid or gaseous component emanating into a liquid or gaseous intervening medium.

In principle the method according to the invention is applicable to any mineral prospecting requirement where a suitable volatile component can be identified and appropriately detected. A further application of the method of the present invention is the detection and location of mines by sensing of a suitably chosen volatile component of the mine.

C L A I M S

1. A method of determining the position and emission rate of at least one source of emanations into an intervening medium, which method comprises:
(a) selecting a set of measurement locations;
(b) measuring the concentration of the emanations in the intervening medium at the measurement locations to obtain a set of observed data;
(c) measuring the velocity of the intervening medium at a location;
(d) postulating a dispersion model that allows the calculation for a position of the concentration of the emanation arising there from a source;
(e) postulating a set of source models consisting of source parameters, such as the position(s) of assumed source(s) and assumed emission rate(s);
(f) calculating with the dispersion model for each postulated source model the concentration that would arise at the measurement location(s) to obtain a set of synthetic data for each postulated source model;
(g) comparing the set(s) of synthetic data with the observed data to obtain the source model that gives the closest fit; and
(h) outputting the position and emission rate of the at least one source assumed in the source model that gives the closest fit,
wherein the concentrations of the emanations are measured by means of point measurements using an ultra-sensitive detector with an appropriate response time.

2. A method of remotely determining the position of a hydrocarbon reservoir located in an earth formation, which method comprises:

(a) selecting a set of measurement locations;

(b) measuring the concentration of a selected component in the atmosphere at the measurement locations to obtain a set of observed data;

(c) measuring the wind velocity at a location;

(d) postulating a dispersion model that allows the calculation for a position of the concentration of the selected component arising there from a source;

(e) postulating a set of source models consisting of source parameters, such as the position(s) of assumed source(s) and assumed emission rate(s);

(f) calculating with the dispersion model for each postulated source model the concentration that would arise at the measurement location(s) to obtain a set of synthetic data for each postulated source model;

(g) comparing the set(s) of synthetic data with the observed data to obtain the source model that gives the closest fit; and

(h) outputting the position and emission rate of the at least one source assumed in the source model that gives the closest fit to obtain a representation of the position of the hydrocarbon reservoir,

wherein the concentrations of the emanations are measured by means of point measurements using an ultra-sensitive detector with an appropriate response time.

ABSTRACT

LOCATING A SOURCE OF EMANATIONS

A method of determining the position and emission rate of at least one source of emanations into an intervening medium, which method comprises measuring the concentration of the emanations in the intervening medium at selected measurement locations to obtain observed data, and measuring the velocity of the intervening medium; postulating a dispersion model; postulating a source model consisting of source parameters, such as the position(s) of assumed source(s) and assumed emission rate(s); calculating with the dispersion model for a postulated source model the concentration that would arise at the measurement location(s) to obtain synthetic data for the postulated source model; comparing the synthetic data with the observed data to obtain the source model that gives the closest fit; and outputting the position and emission rate of the at least one source assumed in the source model that gives the closest fit, wherein the concentrations of the emanations are measured by means of point measurements using an ultra-sensitive detector with an appropriate response time.